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National Pesticide Policy: A Call for Action

Leon G. Higley
University of Nebraska - Lincoln

Michael R. Zeiss
Iowa State University

Wendy Wintersteen
Iowa State University, wwinters@iastate.edu

Larry P. Pedigo
Iowa State University

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Abstract
PESTICIDE USE and regulation have been major public issues for many years. Environmental groups, the pesticide industry, legislators, and growers are frequently at odds over pesticides. Nonetheless, basic questions remain unanswered. What are the fundamental issues and choices regarding pesticide policy? What is the tech nical basis for making policy decisions? The time has come for a rational public debate on these questions. Although national pesticide policy derives from the Federal Insecticide, Fungicide, and Rodcnticide Act (FIFRA) and regulations of the Environmental Protection Agency (EPA), inadequacies in current legislation and regulation are becoming increasingly apparent.

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National Pesticide Policy: A Call for Action

LEON G. HIGLEY, MICHAEL R. ZEISS, WENDY K. WINTERSTEEN, AND LARRY P. PEDIGO

PESTICIDE USE and regulation have been major public issues for many years. Environmental groups, the pesticide industry, legislators, and growers are frequently at odds over pesticides. Nonetheless, basic questions remain unanswered. What are the fundamental issues and choices regarding pesticide policy? What is the technical basis for making policy decisions? The time has come for a rational public debate on these questions. Although national pesticide policy derives from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and regulations of the Environmental Protection Agency (EPA), inadequacies in current legislation and regulation are becoming increasingly apparent.

Two developments in particular have created a pressing need for new pesticide policy. First, public concern over pesticide safety is increasingly being expressed in legislation. For example, California's "Big Green" Proposition 128 (which was defeated) would have canceled registration of all carcinogenic pesticides even if no viable replacements were available. Although some public concerns about pesticide safety may seem more emotional than rational, they have already begun to shape future policy. Indeed, even local governments may soon begin drafting pesticide legislation. In June 1991, the U.S. Supreme Court ruled that FIFRA does not prohibit state or local governments from enacting pesticide legislation that is more restrictive than FIFRA itself (case no. 89-1905). This opens the door for individual townships to declare themselves pesticide-free zones, and "raises the specter of gypsy moth hoards safely navigating through thousands of contradictory and ineffective municipal regulations" (Supreme Court 1991).

The second reason for reexamining pesticide policy is that current regulations do not protect adequately against risks such as development of pest resistance. Currently, pesticide resistance is a problem reaching crisis proportions. The lost usefulness of pesticides through resistance has serious economic consequences and limits management options for medical and agricultural pests. Just as pesticide policy is directed to preserve the environment, so should it provide for pesticide conservation.

For both of these reasons, there is an immediate need for all concerned groups to begin working together to develop a national pesticide policy. In a democracy, citizens' concerns *should* shape policy. But it is in everyone's interest to ensure that concerns are rational and balanced before they are codified into law. Many organizations and individuals have already published studies and position papers urging a reduction in agricultural pesticide use (e.g., National Research Council 1989a, Curtis et al. 1991, Pimentel et al. 1991). The active participation of scientists, particularly entomologists, is essential to developing a rational pesticide policy. Therefore, one of the goals of this article is to encourage the Entomological Society of America (ESA) to develop and publicize specific recommendations for future pesticide policy.

"Pesticide resistance is a problem reaching crisis proportions."

Ultimately, however, only Congress can provide a comprehensive national pesticide policy. In developing policy, legislators must consider two questions: by what criteria should pesticide policies be evaluated, and which criteria are met by which policies? To address these questions, we will examine the fundamental need for pesticide policy and discuss specific criteria for evaluating pesticide policies.

Additionally, we will critique commonly proposed policies and outline others that seem more promising. Our primary intent is to provide a framework for discussion; many details of even the most promising policies remain to be developed. Nevertheless, we believe clear choices in policy do exist, and we will present our opinions on those choices.

The Foundation of Pesticide Policy

Pesticide regulation and policy must address an array of objective and subjective issues. Indeed, policy is formed by moving from objective questions on pesticide properties or ecological impacts to issues such as risk–benefit analyses, which are intrinsically subjective. Both types of issues are important and necessary to form a successful policy. However, the fundamental need for pesticide policy is driven by objective risks from pesticides. These objective risks are the result of the nature of pesticides and their uses.

The essential features of pesticides include having some level of selective toxicity and persistence, being (relatively) freely disseminated into the environment, and potentially becoming ineffective through overuse. Because of these properties, pesticides present human health risks and risks to the environment through effects on nontarget species and environmental contamination. These various risks may be small or large depending on the pesticide and the circumstances, but some level of risk always is involved in their use. It is for these reasons that pesticide regulation is essential and that reduction of pesticide use is an implicit goal in integrated pest management (IPM).

Identifying and regulating pesticide risks has been an evolutionary process. Initially, regulation focused on human health, and environmental concerns were ignored. Indeed, the absence of any mechanism for banning compounds based on environmental concerns led to DDT being banned because it posed a human health risk (a minor risk at worst) rather than because it was a potent environmental hazard. Now, environmental risks are recognized in regulatory decisions and even weighed against risks to human health. For example, the forthcoming elimination of granular formulations of carbofuran on corn and their

likely replacement by flowable formations, which reduces the risk of avian toxicity but slightly increases the risk to human applicators, demonstrates how important environmental concerns now are in the regulatory process. However, to date, pesticide regulation has not addressed the important issue of preventing or minimizing pesticide resistance. This is more than a question of economics; the loss of pesticides through resistance directly threatens human health by limiting management options for medical pests (the failure of the World Health Organization's malaria eradication program is a striking example of this). Thus, pesticide regulation does not yet deal with all aspects of pesticide risk.

The challenge in developing policy is that objective requirements for human health, environmental safety, and minimizing resistance must be met in the context of economic constraints, public perceptions about pesticides, and associated political realities.

Criteria for Evaluating Pesticide Policies

Minimizing pesticide use has long been a goal of entomologists. Familiarity with problems in pesticide use led entomologists to develop the present paradigm of IPM. The IPM paradigm holds that nonchemical tactics (especially those that do not exert strong selective pressure on pest populations) are inherently superior and that pesticides should be applied only when no viable alternative exists. Thus, entomologists and the many groups calling for reduced pesticide use have a shared goal.

However, sharing a goal does not ensure agreement on how best to attain the goal. Some recently proposed policies for reducing pesticide use seem likely to do more harm than good. To examine existing policy and consider appropriate revisions or additions, it is first necessary to identify the criteria by which pesticide policy should be judged. A successful pesticide policy must balance at least five potentially conflicting criteria.

Curative Interventions for Correcting Pest Outbreaks. Although pest managers should always strive to substitute preventive, nonchemical tactics for curative pesticide use, curative interventions will sometimes be necessary in even the best-managed systems. American agriculture depends on harvests that are relatively stable and predictable from year to year. The capability to cure pest outbreaks is a crucial contribution to this stability. Limiting curative management options therefore would have serious economic and social consequences. Even in years when regionwide yields were high, some individual growers would still be likely to suffer substantial yield reductions. Serious, unpredictable yield reductions would mean untenable economic hardships for many growers. In such a situation, some growers would be forced out of business, and others would probably avoid producing crops having significant risks from pests. Further, occasional years of unmanageable pest outbreaks over a wide area would reduce food supplies and increase prices temporarily but substantially.

Even minor fluctuations in food supplies and prices would have deleterious consequences in the United States and abroad. Although U.S. citizens currently enjoy the world's cheapest food relative to per capita income (U.S. Bureau of the Census 1991, table 1451), lack of money already forces an estimated 5.5 million U.S. children to suffer inadequate nutrition (Rich 1991). Moreover, any policy that noticeably raised food prices likely would be vigorously opposed by even well-to-do voters. In addition, inexpensive U.S. grain production and reserves provide a vital safety net against famine in developing countries. For all these reasons, maintaining an abundant, inexpensive, and stable food supply must be the absolute foundation of all pesticide policy. As a corollary, curative pesticides also are essential as a management option for medically important pests.

Some nonchemical tactics show promise as curatives (e.g., insect pathogens bioengineered for increased virulence or inundative releases of parasitoids). In the short term, however, only pesticides will allow growers to control pest outbreaks reliably and cost effectively. Therefore, a rational pesticide policy must allow the use of curative tactics to avoid instability in food supply or prices and management options for medical pests.

Minimize True Risks of Pesticide Use. Although pesticides and nonchemical tactics create the same categories of risks, the magnitudes of risks associated with pesticide use are unquestionably greater.

One risk associated with pesticide use is toxicity to humans. This comprises poisonings of applicators and other agricultural workers before harvest, consumption of residues on food after harvest, and indirect exposure via contaminated environmental resources (e.g., ground or surface waters).

Another risk is toxicity to other nontarget organisms, including pollinators, livestock, and wildlife. One group that deserves special mention is arthropod natural enemies. Destruction of natural enemies by pesticides can cause resurgence of target pest populations (requiring multiple applications) or outbreaks of secondary pests released from the constraints of biotic control.

A third risk is environmental contamination. Contamination of environmental resources reduces their utility even when it does not cause toxicity to nontarget organisms. For example, if a source of drinking water becomes contaminated, an alternative water supply system would have to be developed.

A final risk of pesticide use is selection of resistant pests. The selection pressure imposed by pesticide use often results in the development of resistant pest populations. The direct result of resistance is the reduced effectiveness of one or more pesticides, with potentially serious consequences for crop production and for managing medical pests. Moreover, diminished usefulness of safer pesticides may increase use of less safe compounds. Additionally, pesticide resistance indirectly causes substantial capital and labor to be committed to the continuous pursuit of novel toxicants. Other management tactics also may result in resistance, but probably not as much as pesticides.

Minimize Perceived Risks of Pesticide Use. It cannot be emphasized too strongly that it is the risks that the public *perceives* as associated with pesticide use, rather than the true risks, that will shape pesticide policy. Although pesticides may not pose the actual health risk of smoking or driving a car, certainly the perception of risk is greater (Pimentel et al. 1991). Moreover, such comparisons of actual versus perceived risks ignore the distinction between risks that can be controlled by individuals and risks that cannot. Failure to consider public perceptions greatly contributed to the Mediterranean fruit fly crisis in California (Jackson & Lee 1985). Indeed, a consideration of social concerns is essential for effective pest management (Czerwinski & Isman 1986). Thus, policy makers cannot simply dismiss public concerns as exaggerated. These concerns must be addressed by a rational pesticide policy to preclude public pressure forcing the adoption of irrational policies.

Encourage Development and Use of Nonchemical Tactics. The preceding criteria are concerned with making pesticide use more rational. However, given the risks associated with pesticides, merely rationalizing pesticide use is not enough. In addition, pesticide policy should seek to increase the availability and decrease the cost of nonchemical tactics relative to pesticides.

Minimize Costs to Pesticide Users and the Government. Increasing production costs of crop producers would weaken their ability to remain in agriculture. In the long term, significantly increasing production costs would be likely to increase economic instability and reduce the competitiveness of American agriculture. Producers could

tolerate increased costs if they were paralleled by increased sales revenues. As was previously discussed, however, increasing food prices would probably increase malnutrition and trigger a political backlash.

Nor would voters tolerate substantial increases in governmental regulatory expenses. Current efforts to monitor and control pesticide pollution cost at least $150 million a year (Pimentel et al. 1991). Recent tax-cutting initiatives in various states and municipalities indicate voters' unwillingness to accept tax increases, even in exchange for increased government services.

Obviously, changes in pesticide policy cannot be accomplished without some costs. Consequently, methods to accommodate these costs must be an important factor in evaluating potential policies.

No single policy meets all five criteria discussed previously. Nevertheless, by combining several complementary policies, each of which meets criteria that the others do not, all five criteria can be met. In the following two sections, policies will be evaluated according to these criteria. Policies and the criteria they meet are summarized in Table 1. With the exception of a total cancellation of pesticide use, the policies are not mutually exclusive; several could be adopted simultaneously.

Table 1. Potential pesticide policies and criteria met by those policies

	Criteria met by policy					
	Rationalizes pesticide use			Encourages use of nonchemical tactics	Minimizes economic impact	
Policy	Allows curative pesticide use	Reduces true risks of use	Reduces perceived risks of use		Reduces cost to pesticide users	Reduces cost to government
Policies concerning pesticides						
Maintain status quo	X	—	—	—	X	X
Cancel all pesticides	—	X	X	X	—	X
Cancel Class I poisons	X	X	?	?	?	X
Improve existing regulation	X	X	?	—	X	—
Provide financial support to reduce use	X	X	?	X	X	—
Establish mandatory prescriptions	X	X	X	—	—	—
Policies concerning nonchemical tactics						
Create pest damage insurance	X	—	—	X	?	?
Revise commodity support programs	X	—	—	X	?	X
Improve regulation of biologicals	X	—	—	X	X	—
Levy fees on pesticides	X	—	—	X	—	X

Policy Options for Rationalizing Pesticide Use

Maintain the Status Quo. Currently, pesticides can be applied whenever a grower deems it necessary, within labeling restrictions. Restricted-use pesticides can be applied only by licensed applicators, but their use is otherwise unrestricted. Many policy makers believe that with slight modifications, the current system can continue far into the future. We disagree. In our opinion, public concerns about pesticide safety will force fundamental changes in this system within ten years. The status quo does not adequately minimize the true risks of pesticide use (e.g., there is no assurance that pesticides are used only when pests exceed some predetermined threshold). Nor does the status quo actively encourage the development and use of nonchemical tactics. Moreover, the present system fails to address the important issue of pesticide resistance. Consequently, we believe debate should be centered not on whether, but on how, to change the current system.

Cancel All Pesticide Use. California's 1990 "Big Green" initiative illustrates the popular appeal of simply canceling pesticide use. This approach would minimize governmental costs. However, such a policy is too inflexible to accommodate diverse pest management requirements. Preventive nonchemical tactics could probably be substituted for some curative pesticide use without reducing the predictability of yields. Indeed, Pimentel et al. (1991) estimated that yields would not decline and food prices would rise less than one percent if half the chemicals now applied to crops were replaced by other control techniques. Even if this estimate is accurate, however, some curative tactics will always be needed to maintain a stable, affordable food supply. Most arguments for canceling all or most pesticide use do not consider the issues of stability in production and pest outbreaks. For most pests, pesticides are the only reliable curative tactic currently available. Therefore, cancellation is not an appropriate pesticide policy.

A related option that has been suggested is to reduce pesticide use nationally by 35–50%, as is under way in some European countries (Pimentel et al. 1991). Strictly speaking, this is not a policy option; it is a policy goal. Discussions we have seen do not focus on the issue of preventive versus curative pesticide use, nor do they address the issue of economic stability in crop production, both of which are crucial questions in pesticide use. As a focus of policy, setting an arbitrary percentage reduction in pesticide use within a given time seems to ignore the rational criteria that should be the basis of pesticide policy. However, this goal does have the important virtue of addressing public perceptions about pesticide use. Consequently, reductions in pesticide use might be an appropriate secondary goal or measure of success for a comprehensive pesticide policy based on the criteria previously discussed.

Cancel Only Use of Class I Poisons. Class I poisons are those that have acute oral LD_{50} <50 mg/kg and dermal LD_{50} <200 mg/kg. The noted toxicologist R. L. Metcalf (1980) endorsed this policy, stating, "In the U.S. this would restrict or eliminate production of about 130 million lb of highly hazardous and generally obsolete biocides that are chiefly responsible for the human pesticide poisonings." Use of some of these pesticides has already been prohibited. However, the remainder includes some of the most effective curative tools in agriculture. There may be situations in which a highly toxic pesticide would be the most appropriate management tool. Moreover, pesticide safety is a function of persistence, as well as toxicity. It is therefore more rational to restrict the use of Class I poisons than to prohibit it.

Improve Existing Regulation and Registration of Pesticides. The existing system of pesticide regulation and registration meets many important needs, especially those of human and environmental safety. However, modification of existing regulation could greatly improve its effectiveness. Among the areas that merit improvement are the following.

Registration. The system by which pesticides are evaluated for registration basically

is sound. However, manufacturers can afford the money and time required for registration only for pesticides with the potential for high-volume sales (i.e., pesticides intended for major crops and pests). Manufacturers are therefore less likely to develop narrow-spectrum pesticides, or to seek tolerances for minor crops. The same problem exists for toxicants that were registered before 1984 and must therefore be reregistered by 1997. For example, the relatively safe but effective pesticide malathion might not be reregistered for many minor crops and situations for which it is currently used because profits from those uses do not justify reregistration expenses (Simmonds & Brosten 1991). In response to the equivalent problem ("orphan drugs") in the pharmaceutical industry, the federal government established programs to defray a portion of the cost of registering valuable but less-profitable drugs. Establishment of such a program for pesticides might favor maintenance and development of safer toxicants. The USDA already has a program (IR-4) to assist minor-crop reregistrations. However, additional efforts are needed to support reregistration of valuable, but minor-use, pesticides.

Carcinogenicity. A second registration-related issue is the Delaney Clause of the Food, Drug, and Cosmetics Act. The Delaney Clause does not allow the use of any carcinogenic pesticide on crops if that pesticide accumulates in processed foods. However, carcinogenic pesticides may be applied to crops that are not processed, and carcinogenic pesticides may be applied to crops if the pesticide does not accumulate in processed foods. This inconsistent policy is further undermined by the EPA applying the Delaney Clause only to new pesticides, thereby exempting some older compounds that are significantly less safe than newer compounds (National Research Council 1989a). Problems with the Delaney Clause are part of a larger debate over what actually constitutes proof of carcinogenicity and what are acceptable risks. Setting aside the issue of proof, a more rational approach would acknowledge that cancer is only one of the possible risks and would allow trading off one risk against others. Permitting the use of pesticides that caused a negligible (e.g., one in a million) risk of cancer but were otherwise relatively nontoxic could reduce the true risks of pesticide use (National Research Council 1987).

Efficacy. A third policy issue is the need for formal efficacy testing. FIFRA states that a manufacturer must prove a pesticide is efficacious in order to receive EPA registration. However, subsequent amendments allow the EPA to waive the efficacy provisions. Formal efficacy testing would assure potential users that less-hazardous toxicants were nonetheless effective. Similarly, users would be provided with evidence as to whether reduced rates (discussed below) were effective.

Application Rates. EPA regulations already require that application rates (quantity of active ingredient per unit area) be listed on pesticide labels. Pedigo & Higley (1992) discuss the possibility of substantially reducing rates. This approach would reduce risks of nontarget effects and environmental contamination but might under some circumstances increase the risk of resistance. Even under ideal conditions, only 50% of the chemical sprayed from aircraft and only 25% of ULV formulations lands on the target crop; the remainder goes into the environment (Pimentel et al. 1991).

> "Legislation should reduce risks to U.S. citizens while recognizing the legitimate needs of other countries."

Consequently, greater emphasis on appropriate application methods also could contribute to decreased application rates.

Export of Pesticides. Current regulations permit the export of pesticides that are not registered for use in the United States. Such export potentially increases the true risks of pesticides for two groups of consumers (U.S. General Accounting Office 1989). First, export of unregistered pesticides may expose citizens of countries with less-stringent pesticide regulations than the United States to increased risk. In particular, pesticide users in developing countries may lack the training needed for safe use of unregistered pesticides. It can be argued that the risk of malnutrition in developing countries could outweigh the risks created by the use of unregistered pesticides. Further, arthropod-borne diseases pose high risks to developing countries, possibly justifying the use of pesticides unregistered in the United States. Nonetheless, export of unregistered pesticides also may expose U.S. citizens to risk via residues on imported food (the so-called "circle of poison"). The proposed "Circle of Poison Prevention Act of 1991" would have prohibited the export of pesticides that were not registered for use in the United States or did not have a food tolerance, but this bill was defeated. Ideally, appropriate legislation should reduce risks to U.S. citizens while recognizing the legitimate needs of other countries. More likely, enacting legislation similar to the 1991 bill would help reduce risks to U.S. consumers, though possibly at the expense of citizens of other countries. Despite this dilemma and the failure of the 1991 bill, given the real and perceived risks associated with unregistered pesticides, current policies seem to be untenable.

Other Changes. A variety of other changes or additions could improve current policy. Among these are standardization of pesticide labels, requiring greater information on the impact of pesticides on natural enemies, and greater support for and emphasis on IPM practices.

Establish Financial Supports for Reduced Pesticide Use. Using incentive payments to encourage reduced pesticide use would provide a voluntary mechanism for reducing producer reliance on pesticides while still maintaining a reliable food supply. Through this approach, potential yield losses would be offset by reduced chemical and application costs, reduced environmental costs, and increased government financial aid. In response, farmers would naturally seek to improve application methods, decrease application rates, use IPM techniques and consultants, and employ nonchemical tactics such as rotation.

The Agriculture Stabilization and Conservation Service (ASCS) established a trial program in 1990 that incorporates some of these ideas. The ASCS Integrated Crop Management program provides cost-share payments to farmers for practices that reduce pesticide and fertilizer use. The program requires that an approved consultant work with the farmer to develop and implement management plans to decrease chemical use. Among examples of permissible cost-shared expenses are scouting services, soil testing, consultant fees, and equipment modification.

An alternative approach would be the establishment of a county-by-county average pesticide-use base. Farmers enrolling in the program would receive either government payments or eligibility for price supports if they could document pesticide reductions relative to the base, with payments or levels of commodity support dependent on the degree of reduction. Ideally, such programs could be financed via reductions and revisions in the present commodity support program. Although costs and political opposition to government incentive payments are unlikely to allow this policy to be used indefinitely, it would provide a

rapidly implementable, short-term approach to reducing pesticide use. Additionally, it could serve as a transitional policy in a move to more substantial policy changes such as pesticide use by prescription.

Pesticide Use Exclusively by Prescription. Prescription pesticide use is a system in which pesticide can be applied legally only after a licensed prescriber has evaluated a pest problem and established that an application is needed. Eminent entomologists such as van den Bosch (1978) and Metcalf (1980) have advocated prescription pesticide use, although they did not discuss details of implementation.

Pesticide prescriptions should consider the pest and its population level, potential economic impact of pest activities, site characteristics, the availability of nonchemical management tactics, and potential environmental effects from management. The prescription should be based on the prescriber's judgment, although formal decision aids such as economic injury levels and economic thresholds would be of great value in supporting prescriptions. It should state first why an application is needed and, second, specify active ingredient, formulation, rate, and application method. If more than one active ingredient, formulation, etc. were acceptable, this array of appropriate choices should be indicated on the prescription. The prescription should be a legal prerequisite to pesticide use, and it should provide a written record of that use.

Prescriptions should not be required for noncommercial (e.g., homeowner) applications of reasonably safe pesticides. However, all agricultural pesticides should fall under prescription requirements. It might be argued that less hazardous pesticides do not need such regulation, but excluding such compounds from prescription requirements is likely to lead to their overuse. Moreover, prescription provides a comprehensive approach for proper pesticide use that would be less effective with exceptions.

The prescribers should be certified professionals who pass certification testing, meet continuing education requirements, and pass subsequent recertification testing. The questions of how many prescribers are needed and possible conflicts of interest remain to be resolved. Use of prescription would require tens of thousands of certified prescribers given the vast agricultural acreage of the United States. Ideally, those making prescriptions should not sell pesticides to avoid any question of impropriety. However, without the involvement of consultants and others who sell pesticides, it seems unlikely that sufficient prescribers would be available. As an interim solution, permitting individuals to prescribe and sell pesticides might be acceptable if stringent enforcement is provided by the agency overseeing prescription (presumably the EPA).

Prescription pesticide use provides many advantages over alternative policies. Unlike other policy options that do not address directly appropriate pesticide use, in principle, prescription guarantees that pesticides are used only when needed. Moreover, prescription provides a method for considering site- and situation-specific details that cannot be included in other policy options. Additionally, prescription would allow direct action to minimize the development of pesticide resistance. In short, prescriptions would provide a mechanism for ensuring the best use of pesticides without requiring vast federal regulations on all details of use. Regarding public perceptions, pesticide prescriptions would provide a professional, accountable system that could restore public confidence in commercial pesticide use.

Some approaches approximating prescription are already being implemented. In California, for example, permits are required from county agricultural commissioners before restricted-use pesticides can be used (Marer 1988). Additionally, many professional organizations are initiating certification programs for those recommending or applying agricultural chemicals. These programs could serve as models for certification of pesticide prescribers.

In many respects, pesticide prescription is a significant departure from existing policy. To the extent that pest managers could no longer freely apply pesticides, it would represent a loss of control. More significantly, it would be more expensive than existing approaches. Governmental costs would include establishing the program, training and testing prescribers, and enforcing compliance. Additionally, someone, presumably producers, must pay prescribers for the prescriptions. These costs are a serious impediment to a prescription system. However, prescription may be inexpensive compared with the costs of losing pesticides to resistance and cancellation.

Obviously, implementing prescription pesticide use would be controversial and would require considerable effort to resolve details of the policy. Moreover, our discussion has not explored all the details and ramifications of such a policy. Nevertheless, pesticide prescription is one of the few policy options (probably the only option) that allows curative pesticide use, minimizes selection pressure from pesticides, and minimizes the perceived risks of pesticide use. Requiring pesticide prescriptions would be one of the most effective means to improve pesticide safety and provide for sustainable pest management.

Policy Options for Encouraging Nonchemical Tactics

Establish Pest Damage Insurance. Growers manage the risk of pest damage indirectly by responding to pest outbreaks via pesticides. Once pests are eliminated, so too is the risk of their damage. An alternative approach is the use of insurance to manage the risk directly. The idea of substituting real insurance for pesticide "insurance" (prophylactic pesticide applications) was proposed by Turpin (1977). In principle, patrons of pest-damage insurance who suffer economic losses from pests would be indemnified by other patrons not sustaining such losses (i.e., the risk would be spread among many producers). Insurance would encourage the use of nonchemical tactics, often perceived by growers as being riskier than pesticides, by reducing the economic consequences of their failure.

USDA currently offers federal Multiple Peril Crop Insurance to growers, which includes insurance against pest losses. However, this is not a palatable alternative to pesticides because coverage only extends to 75% of average yields in a region. In most instances, pest losses would reduce potential yields by less than 25%, precluding reimbursement for loss. Moreover, insured producers are encouraged to apply pesticides as part of standard cropping practices, and it is questionable whether insurance would reimburse producers who had not attempted to prevent losses by applying pesticides. For insurance to replace some pesticide use, either federal policy would have to change or private insurance concerns would need to offer pest damage insurance. However, to date, no private concerns have offered such insurance, suggesting that the potential marketability of the product is low.

Even if pest damage insurance was made feasible (perhaps by mandating its use), significant commodity losses would occasionally be sustained. Such losses, occurring randomly in time and place, most probably would result in instability in supply and unacceptable deviations in commodity prices. For these reasons, pest damage insurance alone would not seem to be a viable alternative to pesticide applications.

Restructure and Reduce Government Price Support Programs. "Many federal policies discourage adoption of alternative practices and systems by economically penalizing those who adopt rotations, apply certain soil conservation systems, or attempt to reduce pesticide applications" (National Research Council 1989a). First, any practice (such as rotation) that reduces base acreage planted to a program crop will

reduce the acreage eligible for federal subsidies for the following five years. The 1990 Farm Bill for the first time allows up to 25% of base acres to be planted to nonprogram crops (Muhm 1991), but additional changes are required to ensure that growers are not penalized for rotations.

A second government policy that blocks adoption of nonchemical control tactics is deficiency payments. Deficiency payments are the difference between the target and market prices of a program crop and are paid for all yield on the base acres. Growers thus seek to maximize yield on these acres, potentially relying on pesticides to guarantee maximum yields rather than basing pesticide use on more traditional cost–benefit criteria. Reducing deficiency payments could reduce pesticide use and save the government billions of dollars. These savings could help defray the cost of establishing a system for pesticide prescriptions or of developing and registering effective biologicals.

Finally, federal marketing orders and grade standards should be revised to reduce purely cosmetic criteria and unnecessarily strict insect-part restrictions (National Research Council 1989a,b; Curtis et al. 1991; Pimentel 1991), although revisions should recognize legitimate concerns regarding the importance of insect parts as allergens.

Improve Registration of Biologicals. The term biologicals refers to organisms and their products. In calling for improved registration for biologicals, it is important to point out that we do *not* support reduced registration requirements for biorational pesticides or biologically produced toxins. Despite perceptions to the contrary, the source of a pesticide, be it natural-product derivative, bacterial toxin, or synthetic chemical, is irrelevant. All are toxic; therefore, all pose some risks. Consequently, all pesticides should be subject to the same evaluation and registration requirements. However, living organisms clearly require special regulatory considerations.

Formal standards and procedures for evaluating efficacy and approving commercial production of living biocontrol agents are a prerequisite for their wide-scale use. Separate standards and procedures likely will be needed for arthropods (predators and parasitoids), pathogens, and genetically engineered agents. Each of these three groups presents different mixtures of risks and benefits, and none is amenable to evaluation via the current pesticide registration system. The USDA Agricultural Research Service (ARS) has taken the lead in drafting nonbinding protocols for importation, quarantine, and release of nongenetically engineered arthropods and pathogens. Hoy et al. (1991) identified key issues regarding commercial releases of arthropod natural enemies. Both ARS protocols and input from researchers should be considered when developing policy. Additionally, formal procedures are needed for evaluating the efficacy of biocontrol agents. These organisms cannot be commercialized successfully to compete with pesticides unless growers have objective assurance of their efficacy. Indeed, producer groups themselves are recognizing this need and beginning to develop policy statements (Association of Natural Bio-Control Producers 1991).

The EPA has taken the lead in developing protocols for genetically engineered organisms; however, current protocols do not address some crucial issues. To reduce the risk of insect resistance, there is an immediate need for policy on deployment of genetically engineered plants producing *Bacillus thuringiensis* endotoxins. As Brattsten (1991) stated, "transgenic crop plants must not be used until appropriate strategies for their use have been designed." Similarly, regulation on the deployment of herbicide-resistant plants also is needed. Again, both existing (i.e., EPA) protocols and the opinions of researchers who would be affected by future regulations should be considered when developing policy. In particular, we are concerned that entomologists and other applied ecologists who can bring substantial knowledge and experience to the question of how to employ properly a new pest management technology seem to have little voice in the regulation of biotechnology.

Levy Fees on Pesticides. The two major barriers to use of nonchemical tactics are higher costs compared with pesticidal control and (in some instances) the absolute lack of effective nonchemical alternatives. Both barriers could be addressed by levying fees on pesticides. A tiered system of fees on pesticides according to their relative environmental and health costs would provide an incentive for selecting the least environmentally hazardous pesticide or nonchemical alternatives. Metcalf (1982) proposed an environmental impact scale for pesticides that was based on mammalian toxicity, nontarget toxicity, and environmental persistence. Higley & Wintersteen (1992) rated pesticides based on their risk to water quality, nontarget organisms, and human health. These scales might be appropriate guides for establishing relative magnitudes of fees on various pesticides. However, fees high enough to influence use patterns significantly seem likely to pose too great a financial burden on pesticide users.

Alternatively, a set fee could be charged on all pesticides regardless of their environmental risks. Such a system is used currently in Iowa, where agrichemical companies must pay a portion of sales receipts to a fund used for grants supporting research on sustainable agriculture (which has greatly increased research and implementation programs on integrated pest management and alternatives to chemical pesticides). Similarly, registration fees at the federal level currently help support registration costs in the EPA.

Revenue to support changes in pesticide policy is needed. Additionally, there is a critical need for funding to support research and implementation efforts in IPM, including support for alternatives to pesticides. Indeed, inadequate support for IPM and nonchemical tactics continues to be a serious barrier to reducing reliance on pesticides (Pedigo & Higley 1992). It seems appropriate that users of toxic tactics should help pay society for the privilege and that resultant revenues should be used to help minimize the effects of pesticides and to search for less-toxic alternatives.

Policy Conclusions

No single proposed policy meets all five criteria for a rational pesticide policy (Table 1). However, complementary policies do exist for meeting all criteria. Of the policies primarily intended to rationalize pesticide use, two seem particularly promising: financial supports for reduced pesticide use and mandatory pesticide prescriptions. Government programs to reward decreased pesticide use would encourage the farmer or applicator to learn better pest management strategies and substitute nonchemical management tactics. Pesticide prescription would have the added advantage of directly ensuring that pesticides are used appropriately, thereby alleviating public concerns about pesticide safety. Prescription pesticide use is one of the most radical policy options we considered; it also is one of the most powerful. Certainly, a number of details on prescription must be resolved and transitional procedures established. Providing financial support to reduce pesticide use seems to be one promising transitional approach to a prescription system. In addition, improving existing pesticide regulations (e.g., improving risk assessment criteria, and minor-use pesticide support) would improve pesticide safety at low cost to the government. Ultimately, however, establishing a system of mandatory pesticide prescriptions may be the only way to allow continued access to curative pesticide use, minimize pest resistance, and improve public perceptions of pesticide safety.

Of the policies primarily intended to encourage development and use of nonchemical tactics, all but insurance seem promising. Revising commodity support

programs and improving regulation of biologicals are immediate policy needs. Levying fees on pesticides to support greater research and implementation efforts could increase the availability and decrease the cost of nonchemical tactics. By combining these policies with policies intended to rationalize pesticide use, all five criteria for a rational pesticide policy would be met.

A Call for Action

For change to proceed rationally, policy must be planned before it is actually needed. Once change is under way, the need for rapid decisions often causes decision makers to be influenced more by emotion than by reason. During the next few years, public concern about pesticide safety will almost certainly necessitate fundamental changes in pesticide policy. At present, however, policy makers still enjoy the rare luxury of having time to plan policy proactively. The opportunity to plan pesticide policy rationally must not be wasted.

In calling for action on national pesticide policy, we must address two groups. The first and most important is Congress. The Supreme Court's ruling on *Wisconsin Public Intervenor v. Mortier* led the court to "reject the position . . . that the 1972 amendments transformed FIFRA into a comprehensive statute that occupied the field of pesticide regulation" (Supreme Court 1991). Indeed, the court emphasizes FIFRA's history as a labeling and registration law rather than as a comprehensive federal statute on pesticide regulation.

Nevertheless, FIFRA is the foundation of national pesticide policy; if it does not provide comprehensive pesticide regulation, what does? Further, as we have argued in this paper, existing policy does not meet current needs and will not meet challenges in the future. Consequently, there is a compelling need for Congress to amend or supplant FIFRA to provide a comprehensive federal pesticide policy. Without action, probable developments include patchwork pesticide legislation across the country, greater controversy and dissent on pesticides between agriculture and the public, and increasingly limited curative management options.

Ultimately, a failure to be proactive in addressing pesticide policy will undermine public trust in the safety of the food supply and thereby reduce pesticide availability and usefulness so seriously that many pest situations will become unmanageable.The other group that needs to act is scientists. Pesticide policy presents many technical challenges including questions of human health and environmental risk, evaluating economic and environmental impacts, and sustaining pest management. Scientists working in these areas understand the scientific evidence and the conflicts that fall beyond the knowable. Because of this background, scientists must become active participants in helping to formulate policy. In this process, it is essential that scientists recognize that scientific opinion is not the same as scientific fact and, further, that public perceptions and concerns, regardless of their rational basis, are legitimate issues that must be addressed.

This argument regarding scientific involvement in policy is especially pertinent to entomologists. Entomology exists as a discipline distinct from zoology not because of the diversity and scientific importance of insects but rather because of the extraordinary impact insects have upon human health, culture, and history. Consequently, entomologists have a special obligation to consider the relationship of their science to society. It would be unconscionable for entomologists to fail to act on issues like pesticide policy that are both central to their scientific expertise and central to the needs of society.

More specifically, because of their role in developing pest management theory, entomologists are uniquely qualified to evaluate the relative merits of various plans for pesticide regulation. However, despite the expertise of its members, ESA has done relatively little to guide future pesticide policy.

The ESA Governing Board recently appointed a committee to draft a statement on the role of pesticides in agriculture, ultimately to be voted on by all ESA members. We applaud the initiative of the Governing Board, and we support the work of the committee.

In addition, however, scientific groups like ESA need to provide legislators with detailed medium- and long-term goals for agricultural pest management as well as specific recommendations for achieving those goals. The ESA should develop a white paper providing a detailed examination of pesticide policy and specific recommendations for future legislation.

We believe our examination of policy needs and options points to some powerful alternatives for future pesticide policy. Identifying such alternatives is one of our goals. Another is to catalyze action by ESA, its members, and other scientists.

Without such action, we fear that inadequate policies will persist and that future policies will be driven by special interests, emotion, and political expediency rather than by rational considerations of risks, costs, and benefits.

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Leon G. Higley is an assistant professor of entomology at the University of Nebraska–Lincoln. Michael R. Zeiss is a research assistant, Wendy K. Wintersteen is an associate professor and director of Environmental Pesticide Programs, and Larry P. Pedigo is a professor in the Department of Entomology, all at Iowa State University. The authors share interests and collaborations in pest management and environmental issues.